The MEMS 5-in-1 RM is a single test chip with test structures for the measurement of dimensional and material properties with the use of five documentary standard test methods (from which its name is derived). To validate the use of the test methods, companies can compare their measurements with NIST measurements on the same test structures. The MEMS Calculator (http://srdata.nist.gov/gateway/ with the keyword "MEMS Calculator") can be used for the calculations.

The five test methods are for measuring Young's modulus, residual strain, strain gradient, step height, and in-plane length. Eight properties are reported; the five mentioned plus residual stress, stress gradient, and beam thickness. Residual stress and stress gradient are obtained from calculations given in the Young's modulus test method. Beam thickness is obtained using the step height test method (as described in NIST SP 260-177). Therefore, five test methods are used to obtain the reported eight properties.

The instruments used for the MEMS 5-in-1 measurements are:

- an optical vibrometer, stroboscopic interferometer, or comparable instrument for the measurement of Young's modulus, and
- an interferometric microscope and/or stylus profilometer or comparable instrument(s) for the measurement of residual strain, strain gradient, step height, in-plane length, and thickness.

There are two types of chips (RM 8096 and RM 8097). RM 8096 was fabricated on a multi-user 1.5 μm complementary metal oxide semiconductor (CMOS) process followed by a bulk-micromachining etch. For this RM, the material properties of the composite oxide layer are reported. Test structures, in addition to those used with the test methods, include: tensile test structures (to measure the Young's modulus of the metal2 layer), thickness test structures (to measure the thickness of all the layers in the CMOS process), and a linewidth test structure (to measure select oxide beam widths after the test structure is covered with a conductive layer). The supply of RM 8096 is limited.

RM 8097 was fabricated using a polysilicon multi-user surface-micromachining MEMS process with a backside etch. For this RM, the material properties of the first (poly1) or second (poly2) polysilicon layer are reported. Test structures, in addition to those used with the test methods, include: linewidth test structures (to measure the linewidth of poly1 or poly2 for select beam widths), thickness test structures (to measure the thickness of the poly1 or poly2 layer and to obtain data for stiction studies), fatigue test structures (to measure Young's modulus, ultimate strength, and fatigue of the poly1 layer), and a 2.5 mm ruler.

Email mems-support@nist.gov for further assistance.

RM Number	**RM Name**	**Chip Size**	**Layer Reported on**	**Effective Young's Modulus and Thickness**
8096	CMOS MEMS 5-in-1 Test Chip	4600 μm by 4700 μm	composite oxide	$E \approx 60$ GPa; $u_{cE} \approx 9$ GPa; $u_{cE}/E \approx 15$ % $t_{oxide} \approx 2.7$ μm; $u_{coxide} \approx 0.1$ μm; $u_{coxide}/t_{oxide} \approx 3.7$ %
8097	MEMS 5-in-1 Test Chip	1 cm by 1 cm	poly1 or poly2	For the poly2 layer: $E \approx 127$ GPa; $u_{cE} \approx 19$ GPa; $u_{cE}/E \approx 15$ % nominal $\alpha \approx 1.375$ μm; $u_{c\alpha} \approx 0.052$ μm; $u_{c\alpha}/\alpha \approx 3.8$ %